SIMULATION BASED ACQUISITION (SBA) -

IS IT TAKING ROOT IN THE DEFENSE ACQUISITION COMMUNITY?

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Overview

Initially, this research was focused on the *substance* of simulation-based acquisition, or SBA, as it is called. However, it soon became clear there is much already written and available in government publications, trade journals, and on the web about the emphasis on using M&S to support the various stages of a new weapon system program. Rather than rehash existing information, this paper focuses on an evaluation and assessment of how well the message is being heard by professionals in government and industry.

This paper describes an evaluation of the state of the art in using modeling and simulation in support of weapons systems acquisition. The research focused on two assessment areas: 1) the terminology in vogue in the modeling and simulation community to communicate with acquirers to convince them of the value of M&S; 2) the maturity of the acquisition and user community with respect to knowledge of and investment in M&S during the acquisition cycle.

Of particular note, the research looked at case studies of programs in various stages of the acquisition life cycle. The focus was on how today's program offices leverage M&S technologies and existing tools to reduce risk and improve the outcomes of weapon system programs. The paper concludes with a summary of the insights drawn from interviews and the literature available on perceived weaknesses in M&S implementation in acquisition, and offers suggestions to address these weaknesses.

Introduction

Defense department guidance and trade publications today are replete with references to "Simulation Based Acquisition" or SBA. This is a relatively new term in the author's 18+ years of experience in the systems acquisition career field in the Air Force. Use of this new jargon became popular in government and trade publications in the late 1990s. However, the use of modeling and simulation during the process of acquiring new weapons is not new. In fact, models and simulations have been part of all nearly all phases of a weapon system program since before computers. For example, wooden aircraft models were used in early development phases, in wind tunnels to simulate flight conditions and identify stress points in a flight profile.[1] Such M&S in early development greatly reduced the risk a human test pilot faced later in the acquisition cycle during developmental or operational flight tests. Today, extensive verification and validation testing can be done using computerized modeling and simulation to collect great quantities of data prior to a putting a human at risk in a live test. The large quantities of data allow much greater statistical confidence in the test results, thereby allowing systems to be developed with very high reliability and maintainability specifications.

The point of the foregoing discussion is not to praise the acquisition community for the splendid initiative known as SBA. Rather, the point is that the use of M&S to support acquisition has progressed to a remarkable degree and has been accelerated by the advent of high capacity and high-speed computer technology. Moreover, M&S support to acquisition happened at the grass roots level and did not require an initiative such as

"SBA" as an enabler. But on its own, this grass roots, distributed effort to incorporate more M&S into acquisition did not reach the next level of importance – it was not an integrated, collaborative effort to share models and broaden the level of operations that are simulated. Thanks to the efforts of Dr. Pat Sanders and others in DoD who followed up on this promising movement, in the past 4-6 years, acquisition literature has become infested with the term SBA.[2] Likewise, the M&S community of experts now recognizes the term as a separate area of specialization within modeling and simulation circles. For example, at the recent Interservice/Industry Training, Simulation and Education Conference, the author interviewed at least 20 separate exhibitors and relevant attendees.[3] To a person, they all recognized the term "SBA" and could recommend several subject matter experts for the author to consult with for follow-up interviews or data gathering. Clearly, the knowledge about DOD's seriousness and zeal in pursuing SBA has reached the M&S community. There is still room to better educate professionals in the acquisition community.

Of note, the author did a non-scientific and anonymous poll of peers in the Air Force and DoD acquisition community and found many individuals in middle management who said something along the lines of, "SBA – yeah, I've heard of it. I think it's a DoD or DSMC initiative or pilot program. JSF is doing it. We just use models and simulations where we need them and where we can afford to add them." This feedback indicated room for greater education of the "middle layer" of acquisition management, as well as new entrants to the acquisition career field. Thus, this research paper focuses primarily on how to better educate as well as how to set up structures and processes to help prevent dilution of SBA benefits. Underuse of modeling and simulation

may merely be due to pure ignorance or inexperience on the part of well-intentioned acquisition leaders who may be doing what they've always done to make a program succeed. In fact, SBA implementation involves a change to doing what we've always done. It also requires up front collaboration among the "requirers" in the operating commands, the operators in the joint community, and acquisition leaders.

Jargon-Check: SBA Terminology Decoder

The articles and defense policies reviewed for this research had many themes in common and used a set of terminology that was difficult to interpret. To truly understand some of the references, one would need foreknowledge of how to develop a model or a simulation to interoperate with other models or simulations. In particular, there were three terms that were the least intuitively obvious. This lack of transparency is an issue discussed later in this paper.

Simulation Based Acquisition (SBA)

The DoD Modeling and Simulation Glossary[4] defines *modeling* as construction of a model which represents some aspects of a (real or imagined) system. A model is a physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process. *Simulation* is defined as the using or exercising of a model.[5] These two terms have clearly separate meanings but are often joined at the hip because models are the operative element in simulations. The combined usage, Modeling and Simulation (M&S), is defined as the process of designing a model of a system and conducting experiments with this model to either understand the behavior of the system or to evaluate various strategies for operating the system.[6] SBA, on the other hand, aims

at having an effect much greater than M&S. The vision of SBA is to foster an "acquisition process in which government and industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs."[7]

Collaborative Environment

Much of the SBA-related literature focuses on the need to develop and maintain a *collaborative environment* as an enabler for SBA. This term is defined as a "permanent or semi-permanent collection of resources, people, processes, and tools assembled to attack a" problem.[8]

As will be discussed later, this jargon is not easy to embrace, even when defined as above.

High Level Architecture

High Level Architecture (HLA) is a standard technical architecture to better enable simulations to interoperate. It is a composable approach to constructing simulations that recognizes that no single, monolithic simulation can satisfy the needs of all users. Thus, HLA provides a common framework within which specific system architectures or federations are *more likely* to be able to interplay. While being HLA-compliant will not guarantee interoperability, it will foster the means to allow interoperability.

Maturity of the Acquisition and User Communities Regarding SBA

The level of education and experience with implementing M&S at the program or mission area level varies greatly across the acquisition community. To jump start the SBA initiative, OSD supported several program-level implementation "pilots".[9] These pilot programs will have a direct payoff for the programs and mission areas; moreover,

they will have an indirect and far-reaching payoff as personnel affiliated with the pilots move on to other projects within the DoD.

As discussed above, nearly all acquisition managers have been exposed to modeling and simulation on their programs, either in the form of threat models, or system models for developmental and early operational testing. But implementing SBA is new to a great many managers in both the using commands and the acquisition community. A quick look at a few "poster children" will help define the learning curve associated with implementing SBA.

Joint Strike Fighter (JSF)

The JSF program has a well-documented and well-publicized program of modeling and simulation support. It was initiated in the formative stage of the program strategy and was referenced in the original program charter in 1994. The DepSecDef-approved charter tasked the

program office to:[10]

- Integrate a team of users and developers
- Conduct tradeoff analyses of critical user defined performance parameters using unprecedented levels of joint analyses and simulation
- Evolve requirements over time
- Reduce future strike systems development, procurement, and support costs

Given the inherent flexibility and empowerment of the users in this charter, the models and simulations used by the JSF team became the backbone of the early requirements trades and the cost vs. performance studies. With the early insights M&S provided prior to actual hardware prototypes, the role of the user in applying the M&S tools was quite pronounced. Because JSF was advertised as a program that would

balance cost vs. performance (as long as certain thresholds were met), the users involved in the requirements trades were comfortable with making requirements changes, if they had data from the simulations to support those changes.

The roadmap to the approval of the Joint Operational Requirements Document for JSF involved several "spirals" wherein industry evolved the design (Lockheed Martin and Boeing were the two competing contractor teams) and provided refined cost estimates.[11] The government user/developer team then determined the affordable threshold requirements for those elements of the design. Each spiral resulted in more of the performance being evaluated against cost. The analysis not only looked at operational performance but also at supportability trades. This spiral process offered the users some concrete feedback upon which to base their requirements decisions prior to a detailed design and prototype stage, where much of the cost flexibility would be locked down.

According to Randy Zittel, an SBA proponent and faculty member at Defense Systems Management College (DSMC), the JSF program took M&S into account in a rather unprecedented way. The JSF design process was carefully structured to use "simulation in every step to determine the next step, and in more collective ways than ever before"[12]. The Joint Interaction Mission Model (JIMM) is the core JSF program simulation through which other models and simulations are run, such as a simulation of the friendly C2 and communications networks, and a tool that models space-based infrared data. Both of these inputs provide data to the JSF cockpit. There is also a system to model enemy radars.[13]

One of the great benefits of the JSF program legacy will be to raise the expectation of requirements officers at using commands regarding how they should take control of requirements trades as cost vs. performance data is generated early in the acquisition life cycle. Many using commands that write ORDs are staffed with young O-4s or O-5s who have significant practical operational experience but little experience with defining *specific* performance requirements. In years past, the decision about ORD performance thresholds was sometimes based on force of personality or the advice of a zealot with a loud voice who had a single, anecdotal piece of evidence about why the performance must be such and such. Now, results from early modeling and simulation offer a more objective basis for users to make prudent trades. These more objective analyses should withstand the scrutiny of higher level review at the MAJCOM level and at the highest levels of OSD or even Congress.

Crusader

The Crusader program is an Army-led development of an advanced self-propelled howitzer. By using a virtual environment, the Crusader program reduced the original requirement for physical prototypes by six. The simulation cost only $9M and it avoided approximately $50M per prototype, or nearly $300M.[14]

Another noteworthy use of M&S by Crusader was in their collaborative development of a cost model based on interviews with experts in design engineering and other subject matter experts.[15] The model helped the program manager work with users to make tradeoffs based on overall contribution to force effectiveness for a given cost. Clearly, the information on these drivers was resident in the key experts so it was available to the acquisition managers. However, it was the added step of integrating that

information into a model, which could be used collaboratively by users and developers, that allowed the benefits of SBA to be realized.

The program office started their force effectiveness analysis even before they issued the request for proposals (RFP) from industry. In preparing their proposals, the contractors did trade studies to determine optimum performance within the overall system that included the Bradley personnel carrier and the M1 tank. They determined that the Crusader could free up the Multiple Launch Rocket System to go more deeply against other targets. This assessment of the overall battlefield impact was valuable information and enabled interpretation by the users so that Crusader requirements were baselined in the context of the larger system of systems.

This example from Crusader telegraphs the importance of a team effort. Without collaboration among the contractors, acquirers, and users, such system-of-system trades may be suboptimized. For example, a contractor might make choices to meet requirements in the RFP in order to be responsive and remain competitive, and ignore the opportunity to recommend that the user change a requirement, based on system of systems performance considerations obtained from a simulation. Thus, bidding contractors must be properly incentivized to use simulation results to the government's best overall advantage. Likewise, it behooves the program office to interact with the contractors during the bidding phase, to capitalize on such opportunities. Achieving this interaction may require separating the program office into two or more teams during a source selection process or a down-select situation.

Future Scout Cavalry System (FSCS)

This program is still in early development and as such, it is ripe for the application of SBA. The Army is considering multiple uses of M&S across the entire development life cycle. The most important facet of the proposed plan is its "system-of-systems" approach. The approach under consideration suggests the following[16]:

> Existing software and hardware can be modified to create the "conceptual capability/system design" as a functioning system on the battlefield. The system could interact with all other combined arms elements on the battlefield. Multiple executions of scenarios can be executed for investigation of possible tactical procedures for use of the "capability/design under test". The analysis could focus on multiple system concepts and multiple procedures for employment of the concepts.

The FSCS SBA effort will merge M&S support from legacy systems with newly developed tools. Moreover, it will be joint with the UK, since the FSCS is planned as a US/UK cooperative program. The international benefits of this pilot program will help pave the way for combined modeling and simulation efforts. This is especially important for the development of new weapon systems most likely to be employed in operations with coalition partners.

Clearly, the lessons from the JSF program implementation have been disseminated, through various conferences and acquisition journals, and have taken root in the planning for the FSCS, as well as for the mission area to which it contributes. The Army developers are aware that a family of models and simulations is needed so each individual weapons system program underway can optimize the performance of the overall system of systems, rather than individual weapon system performance.

Ballistic Missile Defense Office (BMDO)

This paper would be incomplete without giving praise to the robust M&S support integrated with the various programs managed by BMDO. The BMD community developed and continues to develop an extensive array of M&S, wargames, and scheduled exercises for both Theater Missile Defense and National Missile Defense.[17] The level of classification of some of these tools, as well as the breadth of M&S effort, led the author to exclude missile defense programs from the list of case studies addressed. However, it can certainly be looked to for good examples of a stepping stone approach to implementing SBA.

Issues to Resolve for SBA Implementation

Navigating the Minefield of SBA Jargon

As new acquisition managers are schooled through their pipeline training, they will bring SBA knowledge into program offices. It is the "older timers" who may need to catch up. Thus, education of middle managers is a short-term emphasis item and could likely be addressed locally at the various product centers and/or by Program Executive Officers (PEOs). Likewise, using commands that generate requirements are often staffed by more senior officers who have not been to acquisition schooling. They would benefit from continuing education as well as from collaboration with their acquisition counterparts.

A good example is the Army Modeling and Simulation Office (AMSO), which is acting as a clearinghouse and also a help desk for the implementation of the Army's home-grown SBA effort called Simulation and Modeling for Acquisition, Requirements, and Training (SMART). The wealth of information on the AMSO web site was useful to

the author, as a relative newcomer to the specifics of SBA. Through their SMART Program, the Army seems to be doing a creditable job of spreading the word about modeling and simulation. [18] The Army acquisition leadership has also sponsored annual SMART conferences that bring together users and acquirers along with industry. Such venues are where the seeds of a collaborative process are sown.[19] The other Services could piggyback on what the Army and DSMC have already produced in terms of education and training materials.

Understanding HLA-Compliance

Although HLA-compliance is a term frequently seen in trade publications, the importance of being HLA-compliant is not evident to someone unfamiliar with the specifics of what HLA requires. The degree to which a program needs to build HLA-compliant M&S varies with each program. Lack of experience or education can cause programs to either overspecify or underspecify the degree to which their contractor's products must meet the architecture guidelines. Having M&S help-desk resources is a must for HLA to not be perceived as more than it truly is – a help, not an impediment. One source of help is Modeling and Simulation Information and Analysis Center (MSIAC), a center of excellence for modeling and simulation sponsored by the Defense Technical Information Center (DTIC). MSIAC can be reached by program offices in several ways. Moreover, it has an active help desk that can assist in easing a program gracefully into a robust strategy for SBA.[20]

Misplaced Expectations About Improving Program Timelines

Programs that build M&S into their strategy from the start might expect their early development to be shortened and/or costs to be reduced. However, some evidence exists

that the savings do not accrue this early because simulations have some up front cost. This is especially true today, since systems of systems programs have few, if any, models or simulations for the legacy systems. The newer portions of the system of systems development programs must sometimes make up for this. As more acquisition programs fund development of M&S, the follow-on programs will reap additional benefits from this investment.

Another dynamic, evident on competitive acquisitions, may be affecting the use of M&S early in the acquisition program life cycle. Cdr David Brown, a DSMC instructor, conducted a small but controlled experiment to see how the use of a simulation tool early in a program would affect the cost vs. performance trades and the sustainability design of a program. He found that much of what SBA promises was quite valid and laudable, but that the expected schedule and cost of the early development phase of a program may not be reduced. In a competitive environment, contractors will use M&S tools to gain competitive advantage, so they can win the contract. Therefore, they may make more design changes early on, to maximize the results of their simulations[21]. These changes take time and money but the resulting designs are likely to have fewer parts and many more common parts, resulting in more easily manufactured and more sustainable systems. Thus, a more prudent gauge of M&S impact is not early program cost savings but reductions in total cost of ownership. It is important that SBA proponents properly advertise the benefits of modeling and simulation or OSD and Congress will try to harvest financial rewards too early in a program's life cycle.

Acquisition Leaders May Undervalue M&S Investment on Mature Programs

Randy Zittel at DSMC and the Service Acquisition Command focal points are doing a superb job at getting the word out and consulting on the development of new program strategies. Therefore it is likely that new programs will realize much of the benefits that SBA portends to offer[22]. However, there are many programs already underway, especially those in engineering development or later phases, in which the financial benefits of better M&S support may not be reaped. These programs should not be written off as "too mature". Given the life span of many of our existing systems, one can expect production and sustainment phases for most major weapon programs to last 20-35 years. Is this not enough time to benefit from M&S? Moreover, the modeling of existing systems has payoff for the systems of systems in which they operate, as new system simulations incorporate models of legacy systems.

The research for this paper led the author to conclude that there is no shortage of information. However, there is plenty of inertia associated with programs underway, such that an "intervention" of some sort may be needed to get their current leadership to re-evaluate their commitment to M&S development or reuse, to support ongoing requirements trades and sustainability enhancements. Fortunately the ongoing effort to catalogue existing tools (the Services have databases or resource repositories[23], as does the Defense Modeling and Simulation Office) will make it much easier for extant programs to break into the realm of SBA, wherever they are in their life cycle.

Summary: Embedding SBA into the Acquisition Culture

As it has been marketed, SBA is just one of many "initiatives" or top-down levied requirements with which today's acquisition program managers must deal. Because of

the volume and nature of some requirements levied on a program, it can be difficult to satisfy all requirements and still maintain an affordable and executable program. In fact, a prudent program management team quickly learns to sort out the serious and self-evidently important requirements from those that may be time-sensitive or politically motivated and therefore perhaps "soft" requirements. Many times a savvy business leader learns to focus on the intent of a policy or directive, rather than the letter of the requirement. This may be the plateau that has been reached by the various directives and policy guidance put forth across DoD regarding support for Simulation Based Acquisition.

In a program manager's *hierarchy* of requirements, some acquisition leaders may see SBA as merely an initiative, or perhaps an optional requirement that can be set aside if funding constraints do not afford it – it may be perceived as a luxury or an additive cost at the margin. Of course, SBA zealots as well as program managers who have experienced the benefits first-hand know this is misguided logic. Yet helping program managers migrate from "cookbook" application of SBA to embracing it for its benefits during the entire life cycle of a system of systems is the very purpose of SBA, an initiative focused on altering the acquisition culture with respect to M&S.

It is unlikely that the diverse population of acquisition leaders will spontaneously embrace SBA as the goose that will lay golden eggs down the road. Thus, pilot programs such as JSF, Crusader, and FSCS have been supported by the OSD acquisition leadership as a way to gather data and performance statistics to throw gently in the lap of non-believers. Positive results from these early SBA programs, combined with greater

availability of models and simulations in each mission area to support system of systems analysis, will give SBA the shot in the arm it needs to keep it moving toward its vision.

In short, once OSD ceases to call it an initiative and expects each program manager to develop a long range and mission area level view of M&S, then SBA will cease to exist as a separate term. There will be no fork in the road where a program manager must decide to use SBA or not. Then, the acquisition process will be front-loaded with simulations versus hardware prototypes, where practical. Users will be empowered to deal with insights gleaned from simulations and war games and will modify with greater confidence, in light of this learning. Acquisition boards at the Service level and at OSD may even start to review *system of system* requirements and how they are flowed down to programs. Rather than focusing on optimizing individual weapon performance, they may assess overall force effectiveness.[24] These trends demonstrate the real vision of SBA.

Notes

[1] Numerous scale models from the 1920s-1950s are on display in Air and Space museums at the Smithsonian in Washington DC, and at Pensacola Naval Air Station, Pensacola, FL.

[2] "Simulation Based Acquisition (SBA) Status and International Implications," US DoD SBA Paper for TTCP JSA TP-4.doc, September 2000, 1.

[3] Interservice/Industry Training, Simulation and Education Conference, 26-29 November 2001, Orange County Convention Center, Orlando, FL.

[4] As referenced in Air Force Modeling and Simulation Introductory Course – provided for review by the Air Force Agency for Modeling and Simulation, Orlando, FL, Course 1, np, Version dated 26 October 2001.

[5] Ibid.

[6] Ibid.

[7] Patricia Sanders, "Simulation Based Acquisition", briefing for Executive Council for Modeling and Simulation, 23 November 1998, on-line, Internet, 8 December 2001, http://www.dmso.mil

[8] Ibid.

Notes

[9] Randy C. Zittel, "The Reality of Simulation-Based Acquisition – and an Example of US Military Implementation," *Acquisition Review Quarterly*, Spring-Summer 2001, 125-126.

[10] "JSF Modeling Simulation & Analysis", briefing approved for public release by the Joint strike Fighter Program Office. Provided via email from the JSF System Engineering Office on 20 Dec 2001. Slide 2.

[11] Ibid., Slide 5.

[12] Zittel, 129.

[13] Ibid.

[14] DSMC Fellows, "Expanding the SBA Envelope", February 1999, p. 5-7, on-line, Internet, 10 December 2001, available from http://web2.deskbook.osd.mil/htmlfiles/rlframe/refheader.asp?org=&Search

[15] Ibid., p. 5-8.

[16] Dr. Stuart W. Olson, "White Paper Concept for Simulation Based Acquisition For The Future Scout Cavalry System," 22 May 1998, US Army STRICOM, AMSTI-CA, p.7, on line, Internet, 10 December 2001, available from http://www.amso.army.mil/smart/documents

[17] "Theater Missile Defense Programs, Joint Theater Missile Defense Program Efforts, Modeling and Simulation Support," Fact Sheet, on-line, Internet, 18 December 2001, available from http://www.acq.osd.mil/bmdo/bmdolink/html/model.html

[18] AMSO, "Where Do I Get More Information?", 18 May 2001, on-line, Internet, 21 December 2001, available from http://www.amso.army.mil/smart/documents/ref-guide/sec-IV/

[19] Chuck Weirauch, "A real SMART conference," *MS&T Magazine*, Issue 4/2001, 38-39.

[20] Ronald E. Hale, "DTIC IACs, Simulation Based Acquisition (SBA) Support," 17 May 2001, DTIC Briefing, np, on-line, Internet, 10 December 2001, available from http://iac.dtic.mil.

[21] David P. Brown, Cdr, USN, "Simulation Based Acquisition – Can It Live Up to Its Promises," *Program Manager*, Jan-Feb 1999, 12-17.

[22] The author contacted Air Force product center focal points at Electronic Systems Center (Dr. Osama el Bayoumi), and Aeronautical Systems Center (Mr. Larry Beasley). They, as well as contacts from the IITSEC Conference, offered enough information to overwhelm, but were also quite willing to provide staff assistance. The author also easily reached web sites for the Navy, Army, and Air Force materiel command offices responsible for implementing SBA. In addition, numerous academic resources were available through the DSMC web site.

[23] For example, the Navy maintains the Navy M&S Catalog at http://navmsmo.hq.navy.mil/nmsiscat/ and the Air Force Agency for Modeling and Simulation (AFAMS) maintains Air Force M&S Resource Repository at http://www.afams.af.mil.

[24] Zittel, 129.

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